

4.3 CULVERTS AND BRIDGES

This section presents the methods, criteria, and details for hydraulic analysis and design of culverts and bridges. The information presented is organized as follows:

- Section 4.3.1, "Culverts"
 - "Design Criteria," Section 4.3.1.1 (p. 4-37)
 - "Methods of Analysis," Section 4.3.1.2 (p. 4-39)
- Section 4.3.2, "Culverts Providing for Fish Passage/Migration"
 - "Design Criteria," Section 4.3.2.1 (p. 4-51)
 - "Methods of Analysis," Section 4.3.2.2 (p. 4-52)
- Section 4.3.3, "Bridges"
 - "Design Criteria," Section 4.3.3.1 (p. 4-53)
 - "Methods of Analysis," Section 4.3.3.2 (p. 4-54).

4.3.1 CULVERTS

Culverts are relatively short segments of pipe of circular, elliptical, rectangular, or arch cross section. They are usually placed under road embankments or driveways to convey surface water flow safely under the embankment. They may be used to convey flow from constructed or natural channels including streams. The Critical Areas Code (KCC 21A.24) contains definitions of streams (termed "aquatic areas") and requirements for crossing of streams. In addition to those requirements and the design criteria described below, other agencies such as the Washington State Department of Fish and Wildlife (WDFW) may have additional requirements affecting the design of proposed culverts.

4.3.1.1 DESIGN CRITERIA

General

1. All **circular pipe culverts** shall conform to any applicable design criteria specified for pipe systems in Section 4.2.1.
2. All **other types** of culverts shall conform to manufacturer's specifications. See the *King County Road Standards* and *General Special Provisions* for types of culverts allowed in King County right-of-way.

Headwater

1. For **culverts 18-inch diameter or less**, the maximum allowable headwater elevation (measured from the inlet invert) shall not exceed 2 times the pipe diameter or arch-culvert-rise at *design flow* (i.e., the 10-year or 25-year peak flow rate as specified in Core Requirement #4, Section 1.2.4).
2. For **culverts larger than 18-inch diameter**, the maximum allowable design flow headwater elevation (measured from the inlet invert) shall not exceed 1.5 times the pipe diameter or arch-culvert-rise at design flow.
3. The **maximum headwater elevation** at design flow shall be below any road or parking lot subgrade.

Inlets and Outlets

1. All inlets and outlets in or near roadway embankments must be flush with and conforming to the slope of the embankment.
2. For culverts 18-inch diameter and larger, the embankment around the culvert inlet shall be protected from erosion by **rock lining or riprap** as specified in Table 4.2.2.A (p. 4-31), except the length shall extend at least 5 feet upstream of the culvert, and the height shall be at or above the design headwater elevation.

Inlet structures, such as concrete headwalls, may provide a more economical design by allowing the use of smaller entrance coefficients and, hence, smaller diameter culverts. When properly designed, they will also protect the embankment from erosion and eliminate the need for rock lining.

3. In order to maintain the stability of roadway embankments, concrete headwalls, wingwalls, or tapered inlets and outlets may be required if **right-of-way or easement constraints** prohibit the culvert from extending to the toe of the embankment slopes. All inlet structures or headwalls installed in or near roadway embankments must be flush with and conforming to the slope of the embankment.
4. **Debris barriers (trash racks)** are required on the inlets of all culverts that are over 60 feet in length and are 18 to 36 inches in diameter. Debris barriers shall have a bar spacing of 6 inches. This requirement also applies to the inlets of pipe systems. See Figure 4.2.1.D (p. 4-17) and Figure 4.2.1.E (p. 4-18) for debris barrier details.
5. For culverts 18-inch diameter and larger, the receiving channel of the outlet shall be protected from erosion by **rock lining** specified in Table 4.2.2.A (p. 4-31), except the height shall be one foot above maximum tailwater elevation or one foot above the crown, whichever is higher (See Figure 4.2.2.M, p. 4-32).